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Title	A MAC frame structure for IEEE 802.16j multihop relay networks
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Re:	Submitted in response to Call for Technical Proposals for IEEE 802.16j issued on 2006-10-15
Abstract	This contribution describes a MAC frame structure for IEEE 802.16j multihop wireless network. The MAC frame structure enables multihop networking with spatial reuse without the need to modify subscriber station.
Purpose	The MAC frame structure is to be considered for Section 8.4.4 Frame Structure.
Notice	
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Patent Policy and Procedures	

A MAC frame structure for IEEE 802.16j multihop relay networks

1. Introduction

This contribution proposes a MAC frame structure for IEEE 802.16j multihop wireless network. The MAC (medium access control) frame structure enables multihop networking with spatial reuse for the purpose of range extension and throughput enhancement without the need to modify subscriber station (SS) but only Base Station (BS) and Relay Station (RS).

2. MAC Frame Structure

In IEEE 802.16j multihop relay networks [1], downlink transmission is from BS to SS and uplink transmission is from SS to BS. Thus, a RS will transmit for both downlink and uplink traffic compared to BS that can only transmit downlink traffic and SS that can only transmit uplink traffic. In order to realize this multihop realy network, we propose the MAC frame structure as illustrated in Fig. 1.

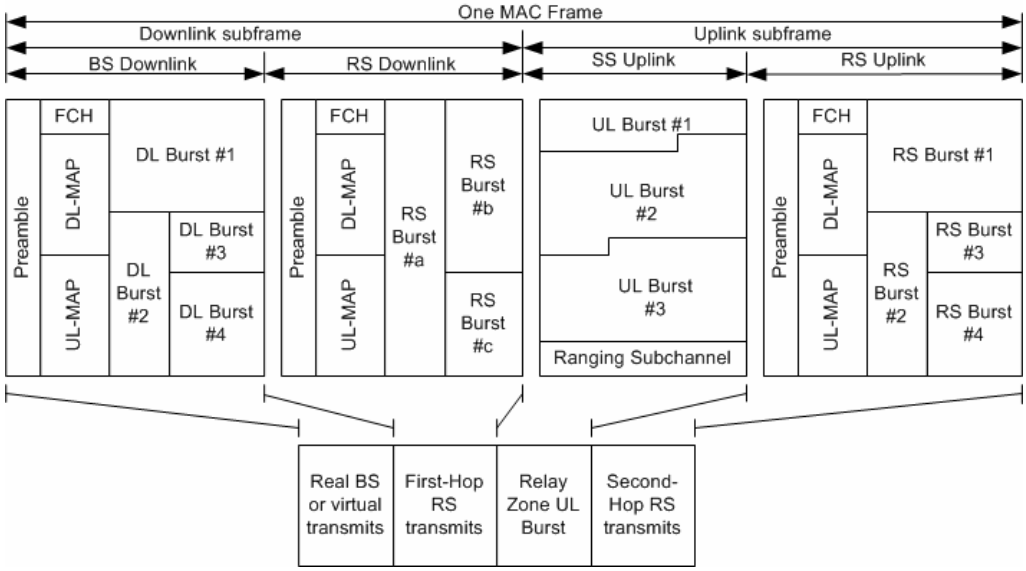

Fig. 1. MAC frame structure (Modification from Figure 218 in the current IEEE Standard 802.16 specification document [3])

One MAC frame is divided into a downlink subframe and an uplink subframe through TDD. The downlink subframe is further divided into two parts, namely BS downlink and RS downlink. The BS downlink part is for a real BS or a virtual BS to transmit. A real BS is the MMR-BS, and a virtual BS is an RS that is perceived as a BS by SS that is not directly connected to the BS. This is clearly illustrated in Fig. 2 where RS2 and RS4 are both virtual BS for respectively relay zone (*p, q*) and (*p, q+1*). Here, the two parameters *p* and *q* are used to uniquely identify a relay zone where *p* is the identifier for a multihop relay chain and *q* is the *q*-th zone in the given *p*-th relay chain.

In the proposed MAC frame structure, a relay zone is defined such that it covers all SS up to those being served by the second-hop RS for a given real or virtual BS. Thus, referring to the example in Fig. 2, {SS1, SS2, SS3, SS4, SS5} is in one relay zone. Similarly, {SS6, SS7, SS8} is in another relay zone that has RS2 acts as its virtual BS. Since different relay zones has its own either real or virtual BS as well as its own set of SS, they can operate concurrently for spatial reuse as shown in Fig. 2.

Similar to the downlink subframe, the uplink subframe is also further divided into two parts, namely the SS uplink and the RS uplink. The SS uplink part is for all the SS in a relay zone to transmit to both BS and its neighboring RS. The RS uplink part is for the virtual BS of the next relay zone to transmit. For example

that is illustrated in Fig. 2, RS which is the virtual BS for relay zone (*p*, *q*) will transmit in this part while the transmission will be perceived as the transmission from BS by {SS6, SS7, SS8}.

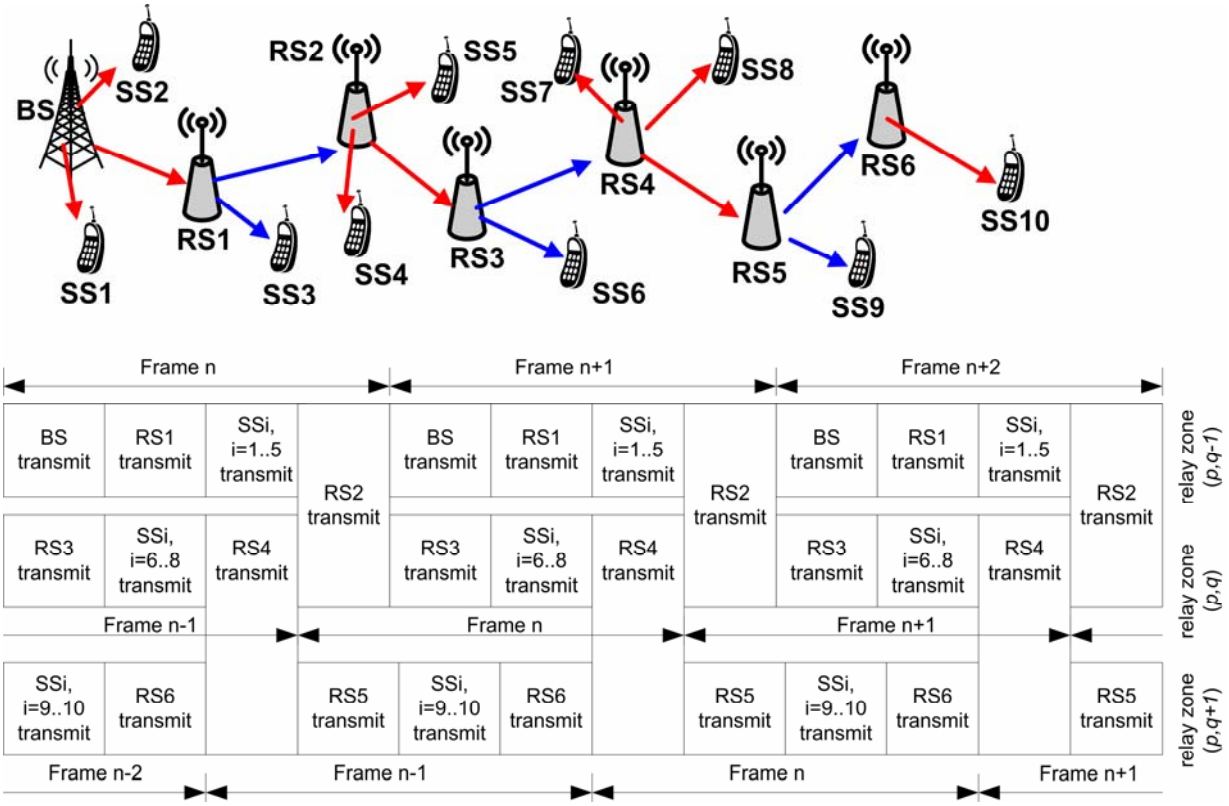

Fig. 2. Example of MAC frame operation for one relay chain

Fig. 2 is a simple example for the case of only one relay chain. However, it is also representative of the case of multiple non-interfering relay chains where non-interfering RS can transmit concurrently as illustrated in Fig 3.

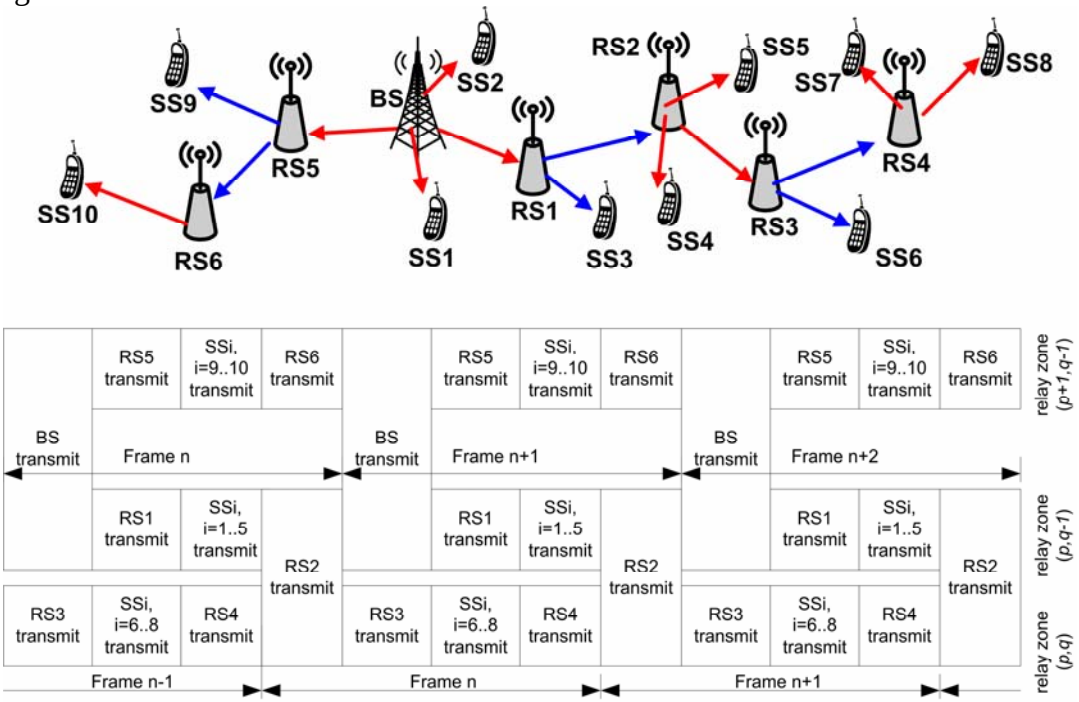

Fig. 3. Example of MAC frame operation for two non-interfering relay chains

The MAC could be more complex when there are multiple interfering relay chains. In this case, the RS downlink part and the RS uplink part has to be shared in the time domain among multiple interfering RS as

shown in Fig 4. Each RS downlink and RS uplink will consume at least a minimum amount of OFDMA symbols. Thus, in a dense network, it is possible that there is no enough OFDMA symbols in a MAC frame to accommodate all RS downlink and RS uplink. When this happens, a superframe will be formed by combining multiple MAC frame such that all RS can be accommodated in a superframe as illustrated in Fig. 5.

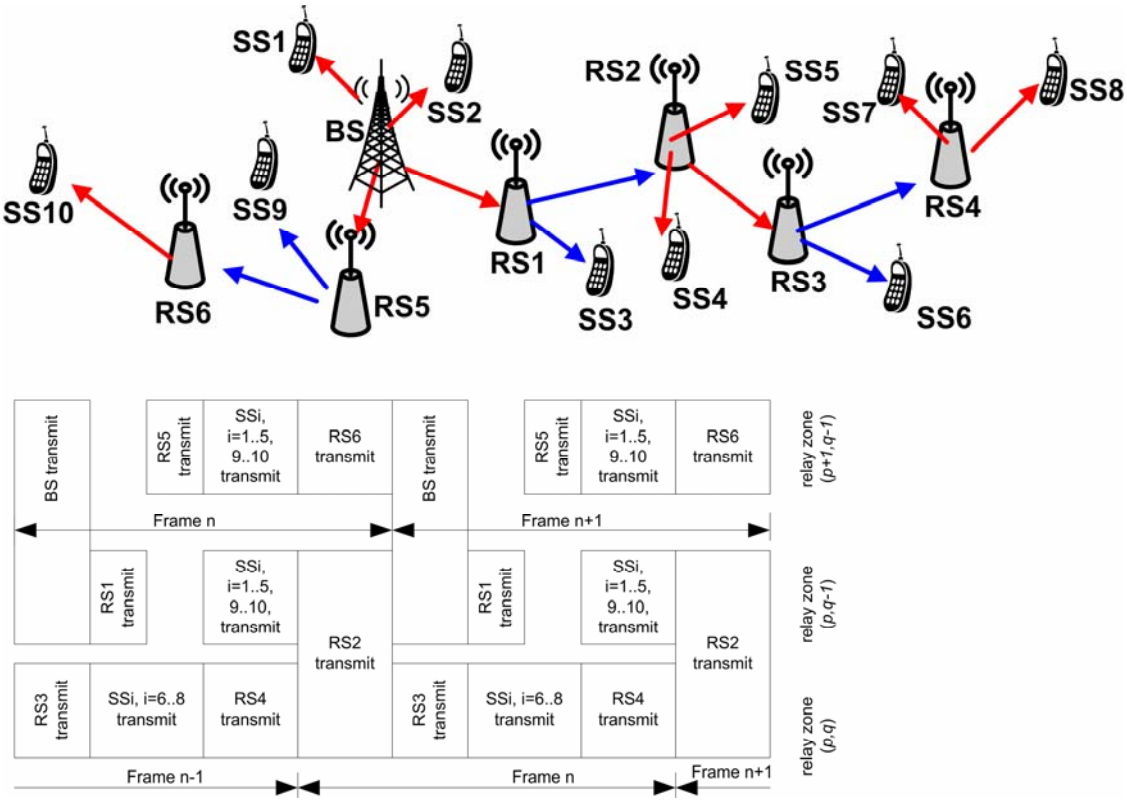

Fig. 4. Example of MAC frame operation for multiple interfering relay chains (RS1 and RS5 have overlapping coverage but not RS2 and RS6)

In Fig. 5, assume that RS1, RS3 and RS5 are within the range of each other. Also, there are three relay chains, namely chain *p-1* for RS5 and RS6, chain *p* for RS3 and RS4, and chain *p+1* for RS1 and RS2. RS2, RS4 and RS6 are not interfering with each other. Assume that each RS downlink is only sufficient for two RS to transmit. Thus, a supeframe that consists of two MAC frame is needed. The number of MAC frames in a superframe depends on the network topology.

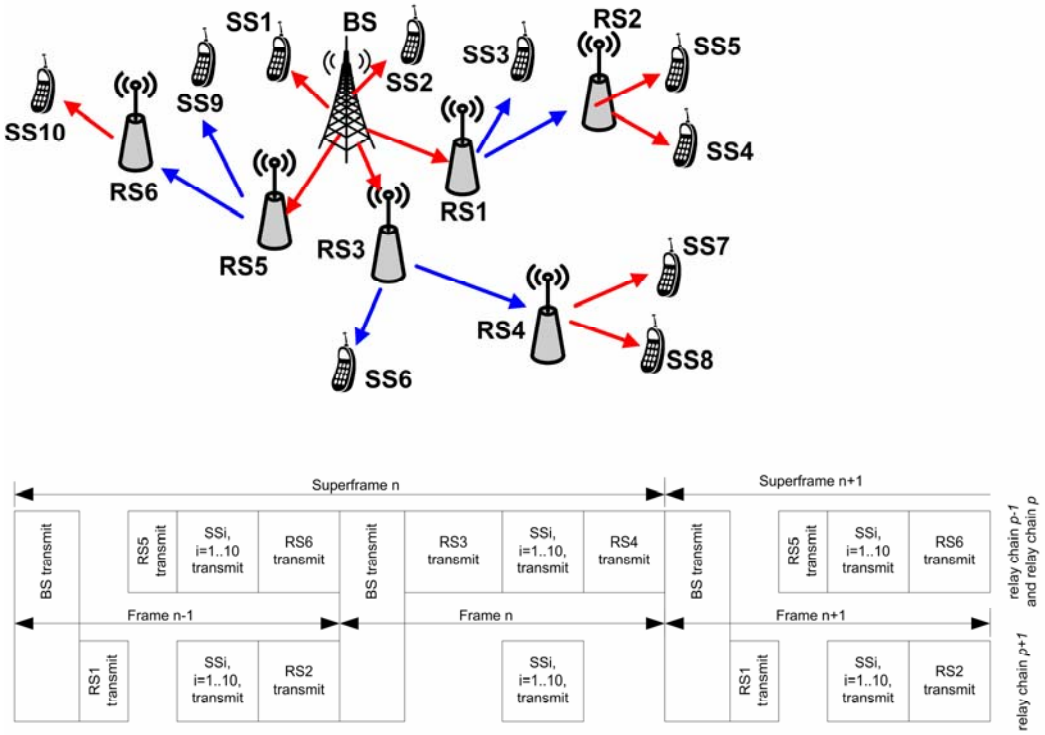

Fig. 5. Example of MAC superframe

For the purpose of throughput enhancement, multihop transmission may be required despite SS is within the range of BS. This will be dealt with as a case of multiple interfering relay chains and an example is illustrated in Fig. 6 where RS7 is introduced for throughput enhancement but not range extension. In Fig. 6, the newly introduced RS7 forms a new relay chain *p+2*.

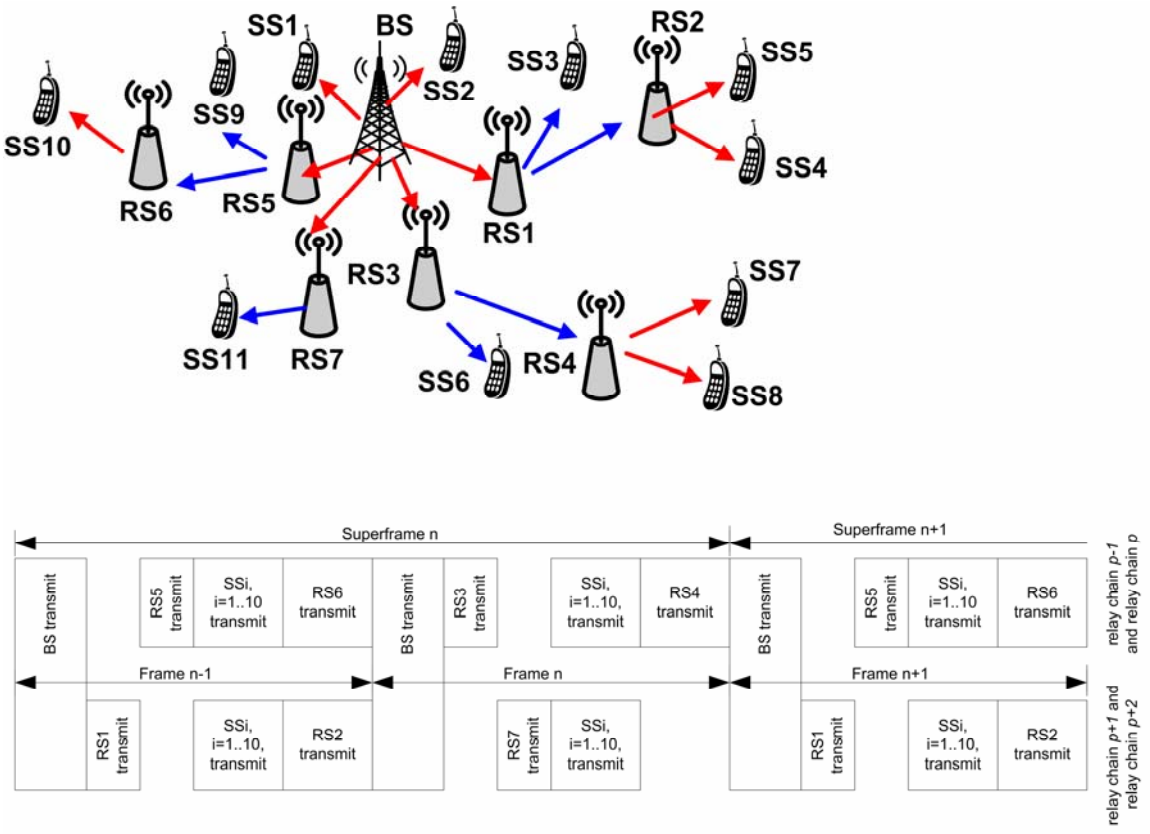

Fig. 6. Example of MAC operation with RS for throughput enhancement

References:

[1] “MMR Harmonized Contribution on 802.16j (Mobile Multihop Relay) Usage Models”, *Document No. IEEE 802.16j-06/015*, 05 September 2006.

[2] “P802.16j - Amendment to IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems - Multihop Relay Specification”, March 2006.

[3] “Part 16: Air Interface for Fixed Broadband Wireless Access Systems”, *IEEE Std 802.16-2004*, October 2004.